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PCT/GB 99 / 00153

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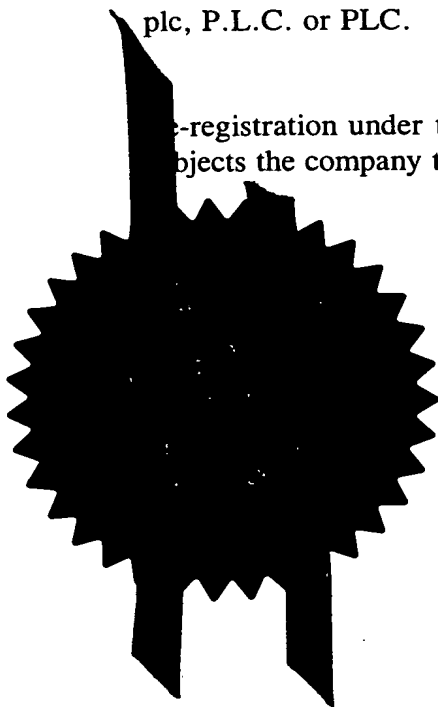
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DAV/P94109

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Please type, or write in dark ink using CAPITAL letters. A prescribed fee is payable for a request for grant of a patent. For details, please contact the Patent Office (telephone 071-438 4700).

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2 Do not give trading styles, for example, 'Trading as XYZ company', nationality or former names, for example, 'formerly (known as) ABC Ltd' as these are not required.

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Request for grant of a Patent Form 1/77

Patents Act 1977

1 Title of invention

1 Please give the title of the invention SURFACE-TRAVERSING VEHICLE

2 Applicant's details

☐ First or only applicant

2a If you are applying as a corporate body please give:

Corporate name
UNIVERSITY OF DURHAM

Country (and State of incorporation, if appropriate)
UNITED KINGDOM

2b If you are applying as an individual or one of a partnership please give in full:

Surname
Forenames

2c In all cases, please give the following details:

Address
OLD SHIRE HALL
OLD ELVET
DURHAM

UK p stc de DH1 3HP
(if applicable)

C untry UNITED KINGDOM
ADP number
(if known)

798215001

2d, 2e and 2f:
If there are further applicants
please provide details on a separate
sheet of paper.

☐ **S cond applicant (if any)**

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3

An address for service in the United
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3 Address for service details

3a Have you appointed an agent to deal with your application?

Yes ☒ No ☐ ➡ go to 3b

↓
Please give details below

Agent's name

URQUHART - DYKES & LORD

Agent's address


ST NICHOLAS CHAMBERS

AMEN CORNER

NEWCASTLE UPON TYNE

Postcode NE1 1PE

Agent's ADP ~~0001644011~~
number

1644019 

3b:

If you have appointed an agent,
all correspondence concerning
your application will be sent to
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3b If you have not appointed an agent please give a name and address in the United
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4 Reference number

4 Agent's or applicant's
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DAV/P94109

5 Claiming an earlier application date

5 Are you claiming that this application be treated as having been filed on the date of filing of an earlier application?

Please mark correct box

Yes ☐ No ☒ ➔ go to 6



please give details below

☐ number of earlier
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15(4) (Divisional) ☐ 8(3) ☐ 12(6) ☐ 37(4) ☐

6 Declaration of priority

6 If you are declaring priority from previous application(s), please give:

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6

If you are declaring priority from a PCT Application please enter 'PCT' as the country and enter the country code (for example, GB) as part of the application number.

Please give the date in all number format, for example, 31/05/90 for 31 May 1990.

7

The answer must be 'No' if:
 - any applicant is not an inventor
 - there is an inventor who is not an applicant, or
 - any applicant is a corporate body.

8

Please supply duplicates of claim(s), abstract, description and drawing(s).

Please mark correct box(es)

9

You or your appointed agent (see Rule 90 of the Patents Rules 1990) must sign this request.

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A completed fee sheet should preferably accompany the fee.

7 Inventorship

7 Are you (the applicant or applicants) the sole inventor or the joint inventors?

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Yes ☐ No ☒ →

A statement of Inventorship on Patents Form 7/77 will need to be filed (see Rule 15).

8 Checklist

8a Please fill in the number of sheets for each of the following types of document contained in this application.

Continuation sheets for this Patents Form 1/77

Claim(s)

Description

11

Abstract

Drawing(s)

2

8b Which of the following documents also accompanies the application?

Priority documents (please state how many)

Translation(s) of Priority documents (please state how many)

Patents Form 7/77 - Statement of Inventorship and Right to Grant (please state how many)

3

Patents Form 9/77 - Preliminary Examination/Search

Patents Form 10/77 - Request for Substantive Examination

9 Request

I/We request the grant of a patent on the basis of this application.

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Date 16/01/1998

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Surface-Traversing Vehicle

The present invention is a vehicle for traversing a surface such as for carrying out an inspection, survey or maintenance operation upon that surface.

In Patent Specification No.GB2305407A we have described a vehicle for this purpose which comprises two bodies interconnected by means to move the bodies towards and away from each other, each said body being supported upon a multiplicity of resilient bristles extending from it. Operation of that vehicle by alternate moving of the bodies towards and away from each other causes it to move in successive steps along a generally linear path over the surface upon which it is supported. The bristles are inclined by a small amount away from being perpendicular to the surface and thereby provide a grip upon that surface which is greater in one direction than in the opposite direction, as determined by the direction of inclination of the bristles.

This foregoing surface-traversing vehicle has proved to be able to move progressively and effectively over a range of different surfaces. When it is required to move in the opposite direction, for example to withdraw from a tubular conduit in which it has been operating, it is necessary for the surface-gripping effect of the bristles to be reversed by reversing the direction of inclination of the bristles. One possible way of achieving that reversal is to rely wholly upon the resiliency of the bristles and to reverse their direction of inclination simply by pulling axially upon the relevant bristle-supporting

body. The reorientation of the bristles may be assisted by rotating the relevant body about its axis.

As indicated in the above patent specification, it could be advantageous if at least one of the bristle-supported bodies were constructed with retractable bristles. However the provision of a mechanically-operated system for retracting such bristles is particularly difficult in the case of surface-traversing vehicles of the present general type in that one important use of such vehicles is in the harsh environments of sewers, oil pipelines and the like, wherein deposited dirt and other sediments can readily impede continued satisfactory mechanical operations. It is perhaps not surprising that no satisfactory provision of such retractable bristles has hitherto been available.

It is therefore an object of the present invention to provide a surface-traversing vehicle of this general type in which a practical and advantageous retraction of the bristles is made possible.

The surface-traversing vehicle according to the present invention comprises two bodies interconnected by means to move the bodies towards and away from each other, each said body being supported upon a multiplicity of resilient bristles extending from it, the bristles of each said body being mounted in groups upon a plurality of bristle-carrying members each guided for movement towards and away from the said body, and fluid pressure means to effect said guided movement of said bristle-carrying members in at least one of said directions.

Thus, by operation of the fluid pressure means associated with one of the bodies, the bristles of that body may be retracted and/or extended as required, to enable their orientation to be

reversed and the body to be moved more readily in its reverse direction, thereby permitting reversal of the direction of movement of the surface-traversing vehicle.

As described in Specification No. GB2305407A, the interconnected bodies which are a feature of the surface-traversing vehicles of the type to which the present invention is applied may be of various shapes depending upon the general nature of the surface to be traversed. Thus they may be generally flat or, for example, rotationally symmetrical, for example generally cylindrical. The bristles may extend generally perpendicularly from the bodies if the bodies are flat. Most usually, the bodies will be generally cylindrical and the bristles will extend generally radially outwardly or inwardly of the body. While the surface-traversing vehicle may comprise generally hollow bodies with inwardly-directed bristles, designed to enable it to progress over the outer surface of a chimney, cable or like conduit, the vehicle is particularly well adapted to use within a tubular pipe, sewer or similar conduit and for that purpose will have outwardly-directed bristles, in particular bristles directed radially outwardly.

The bristles of each of the bodies are mounted in groups upon a plurality of bristle-carrying members each guided for movement towards and away from the said body. These bristle-carrying members may be spaced apart at intervals over the surface of the body but preferably they combine to cover the whole of the relevant surface of the body and therefore lie closely together at one limit of their guided movement. By way of example, in the case of generally cylindrical bodies having outwardly-directed bristles, the bristle-carrying members may each form one angular segment of the cylindrical surface of the body. Preferably such segments are all of

equal angular size, for example 4, 6 or 8 segments each covering, respectively, 90 degrees, 60 degrees or 45 degrees of the cylindrical surface of the body.

The bristle-carrying members are guided so that they may move towards and away from the body upon which they are mounted. Preferably that movement is generally radial with respect to the axis of a generally cylindrical body. To that general end, the axially opposite ends of each bristle-carrying member may be designed to engage generally radial slots or guide channels in the ends of the body. As an alternative, the bristle-carrying members may be mounted upon pins extending through radial apertures or bores in the body, or may themselves slide upon radial pins upon the body.

The movement of the bristle-carrying members towards and/or away from the associated bodies is effected by a fluid pressure means. It is preferred that the latter means be hydraulically, or more preferably pneumatically, operated. By way of example, when the bristle-carrying members each form an angular segment of the body, a fluid membrane, for example a generally cylindrical tubular bag-shaped membrane, may be located along the axis of the body in contact with the radially inner faces of the members. When the membrane is caused to expand outwardly, either by stretching or by unfolding, upon the introduction of, say, compressed air into its interior, the bristle-carrying members are thereby urged outwardly. The latter members may subsequently disengage from the surface being traversed either simply in response to the absence of radially outward pressure or, more positively, under the action of one or more return springs when the fluid pressure is removed.

In one alternative form of the surface-traversing vehicle according to the present invention, the bristle-carrying members are each supported upon a plurality of inwardly-

directed pistons, each arranged to slide, in response to fluid pressure on their inner ends, outwardly within radial, fluid-tight bores within the associated body. The return movement of the bristle-carrying members may, for example, be in response to evacuation of the bores and/or by the action of one or more springs and/or by the resilient action of the bristles themselves.

Whatever the form of the fluid pressure means by which the movement of the bristle-carrying members is effected, it is advantageous to provide also a resilient means tending to resist that movement of the bristle-carrying members. In this way, by varying the pressure of the fluid pressure means, the bristle-carrying members may be set in a selected position intermediate to their fully-retracted and their fully-extended positions. This enables the bristles to be inclined to a greater or lesser extent to take account of variations in the surface being traversed by the vehicle. By way of example, if the frictional value of the surface changes in response to variations in the surface roughness or as a result of the presence of a lubricant on the surface, the inclination of the bristles may be modified to maintain the desired level of grip of the body upon the surface. Similarly, when the vehicle is being used to traverse the interior surface of a hollow conduit, for example of a pipe, the amount by which the bristle-carrying bodies are extended may be modified in this way to compensate for variations in the internal cross-sectional dimensions of the conduit.

Such a resilient means to resist the movement of the bristle-carrying members may take various forms, including for example that of one or more coil springs. However, in a particularly preferred form, the resilient means comprises one or more pieces of a resilient polymeric material, for example an annular piece surrounding an end of the bristle-carrying bodies or one such piece at each end thereof. The polymeric material

may for example be of a resilient polyurethane or a natural or synthetic rubber.

When the surface-traversing vehicle according to the present invention includes bristle-carrying members whose degree of extension can be varied as described above, it is advantageous and preferred to provide one or more sensors to monitor the characteristics of the surface, for example pipe diameter and/or surface roughness, ahead of the vehicle, so that the fluid pressure within each body, and thereby the degree of extension of the bristles, may be modified to take account of any variations in the surface characteristics as the vehicle encounters such variations. The fluid pressure may be modified by the person operating the vehicle or, advantageously, using some form of automatic "intelligent" controller.

The resilient bristles may be of any material having the selected resiliency and may be chosen to reflect the circumstances in which the vehicle is to operate including, among other factors, the load to be supported and/or towed by the vehicle. Thus they may be natural bristles or they may be of a synthetic polymeric material, for example, or of a metal. The selected material preferably has a relatively high stiffness and a good elasticity. It is particularly preferred to use metal bristles, for example of steel, in view of the quick elastic response of such metal bristles. Because, by virtue of the present invention, any required reversal of the direction of inclination of the bristles is greatly aided by the retraction of the bristles, bristles of higher stiffness may be used than would be possible if they had to be re-directed without retraction.

The vehicle moves over the surface in response to the movement of the bodies towards and away from each other. This relative movement of the bodies may be achieved by any desired means, for example by electrical power provided by an on-board source

such as a rechargeable battery or by a remote source via an electrical line. However it is particularly preferred to effect relative movement of the bodies by fluid pressure, in particular by linking the bodies by a hydraulic or more preferably pneumatic cylinder.

Additional support for the bodies may be provided in the form of one or more wheels, whereby the load borne by the bristles is reduced. Such wheels, preferably in pairs, may be located upon the bodies themselves or upon the links between them, for example.

While the surface-traversing vehicle according to the invention may comprise just two of the bristle-supported bodies, it may prove advantageous to provide three or more such bodies. For example, reversal of the direction of operation of the vehicle may be assisted by the provision of a third body and/or the movement of the vehicle overall may be rendered more smooth in this way. In one arrangement, the bodies may be coupled together in pairs, with the two bodies in each pair being coupled at a fixed distance apart, thereby increasing the effective length of each body.

Particularly when the vehicle comprises at least three of the bristle-supported bodies, it is desirable that the required relative movement of the bodies be effected automatically, for example by means of a suitable controller, which may be located either upon the vehicle or at a remote location, to which latter the vehicle may be linked by a direct line or by radio.

When the vehicle is designed to be operated pneumatically, an air line may be provided from a remote source of compressed air to the pneumatic cylinders. That line may be combined with an electrical line, in the form of an umbilical linking a remote control position to the vehicle. The umbilical may in turn be dragged behind the vehicle by means of a similar towing vehicle specifically provided for that purpose. As the vehicle proper

moves further from the control position, supplementary supplementary umbilical tugs may be added. Sensors in the line may monitor tension in the umbilical and in turn prompt an umbilical tug to respond by accelerating or decelerating briefly.

The invention will now be further described with reference to the accompanying drawings, which illustrate, by way of example only, two alternative preferred forms of the bristle-supported bodies of the surface-traversing vehicle according to the present invention and wherein:-

Fig. 1 is a transverse sectional view of the first form of bristle-supported body, with the bristles retracted;

Fig. 2 is an elevation from one end of the body of Fig. 1, with the bristles extended; and

Fig. 3 is a transverse sectional view of the second form of bristle-supported body, with the bristles extended; and

Fig. 4 is a longitudinal sectional view of one end of a variant form of the body of Fig. 3, with the bristle-carrying bodies extended.

The body illustrated in Figs. 1 and 2 is of cylindrical form and is constructed from six bristle-carrying members 10, each forming one sector of the cross-section of the cylinder. The members 10 are shown as solid but may be of a more open construction in order to limit their weight. The members 10 are mounted together between disc-shaped end-plates 11 and each member engages a guide slot 12 at each of its ends, which guide slots permit the members 10 to move by a limited amount radially outwardly relative to the axis of the body. Each of the members 10 carries a large number of bristles 13 distributed throughout the length of its outer curved surface.

Located within a central bore 14 and extending throughout the length of that bore is a generally cylindrical, tubular bag-shaped membrane 15, made of a stretchable rubber material. The membrane 15 may be expanded by the introduction of air under pressure into the interior of the tubular membrane and, in expanding, it drives the bristle-carrying members 10 outwardly, their movement being constrained to a radial path by the guide slots 12. In one form of the invention, the membrane 15 is encircled by a strong restraining sheath, for example of metal foil (not shown), to prevent the membrane entering the gaps which are formed between the members 10 as they move outwardly.

Thus an increase of air pressure within the membrane 15 causes the bristles to move into engagement with the inner wall of a conduit or the like (not shown) within which the vehicle is located and thereby to grip that wall and allow the vehicle to progress along the conduit in the manner described above. Spring means (not shown) may be provided to assist the inward return of the members 10, and thereby retraction of the bristles 13, on removal of the air pressure within the membrane 15. Retraction of the bristles in this way allows the bristle-supported body to be moved axially to redirect the inclination of the bristles.

The form of the bristle-supported body illustrated in Fig. 3 comprises a tubular steel cylinder 20 pierced throughout its length by a number of air-tight bores 21. The bores 21 are distributed in staggered pairs along the length of the cylinder. Within each bore 21, a piston-type pin 22 is slidable. Each of four aligned series of pins 22 supports an elongated bristle-carrying member 23, of arcuate cross-section. The members 23 engage each other to combine to form a cylindrical outer face to the body when they are slid radially inwardly to the maximum extent.

Each pin 22 carries a disc-shaped pressure plate 24 at its inner end. The staggering of the bores 21 as illustrated allows the pins 22 to move towards their radially most inward positions without mutual interference.

Because the bores 21 are air tight, an increase of air pressure within the cylinder 20, acting upon the pressure plates 24, causes the pins 21 to move radially outwardly and in turn to move the members 23, and bristles 25 carried by them, to their outermost positions as shown. In this position, the bristles may engage the inside face of a generally tubular conduit. When it is desired to retract the bristles out of engagement with the surface which is being traversed by the vehicle, the pins 22 are withdrawn radially inwardly by a reduction of the air pressure within the cylinder 20. The retraction of the members 23 in this way may, if desired, be aided by springs provided to act upon the pins 22.

The bristle-supported body of which one end is illustrated in Fig. 4 is closely similar to that of Fig. 3 and like numerals are used to identify like parts. However at each end of the body, a resilient annular "spring" 28 of polyurethane encircles the bristle-carrying members 23 between the outer surface of those members and a flange 26 projecting from the end-plate 27.

The body of Fig. 4 is illustrated in the condition in which the bristles 25 are extended to a maximum extent and in which therefore the spring 28 is fully compressed. However if the air pressure within the cylinder 20 is set at a lower level, then the resilience of the spring 28 urges the members 23 radially inwardly until a balance is reached between the air pressure within the cylinder 20 acting upon the pressure plates 24 and the inwardly-directed pressure of the spring. Thus the degree to which the members 23 and bristles 25 are extended radially outwardly can be set at any time by varying the air pressure in the cylinder 20. In this way, the bristles can be inclined against the inner face of a conduit in which the

bristle-supported body is located, to an angle of inclination appropriate to the internal diameter of the conduit and to the frictional characteristics of the inner surfaces of the conduit. That angle of inclination can subsequently be varied readily by increasing or reducing the air pressure to the necessary extent.



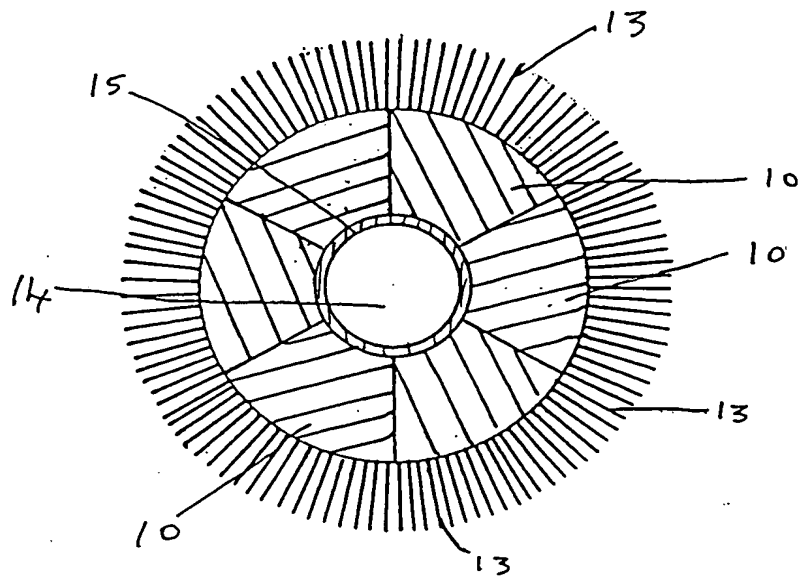


Fig. 1.

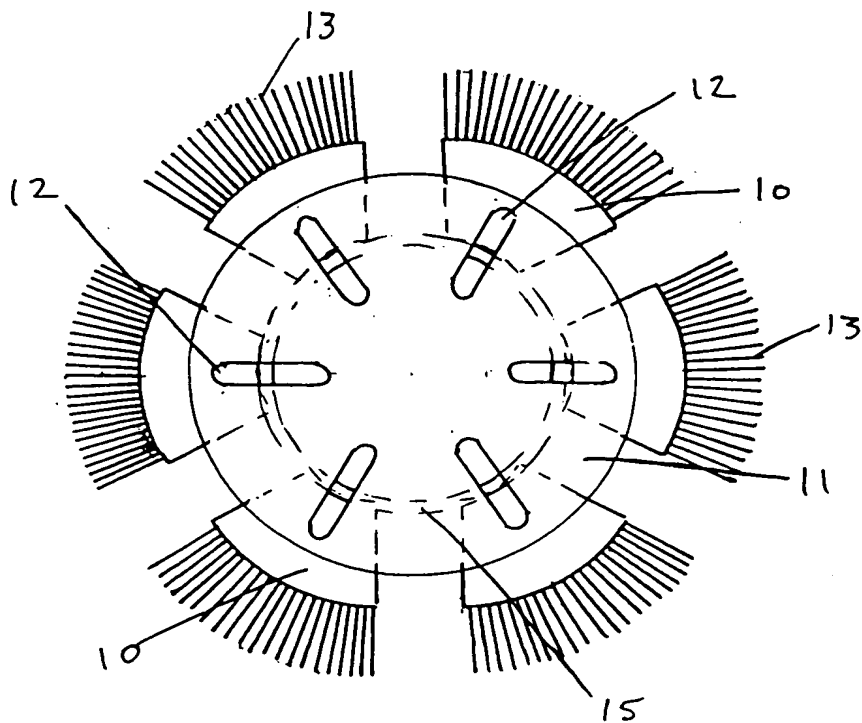
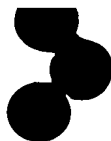


Fig. 2.



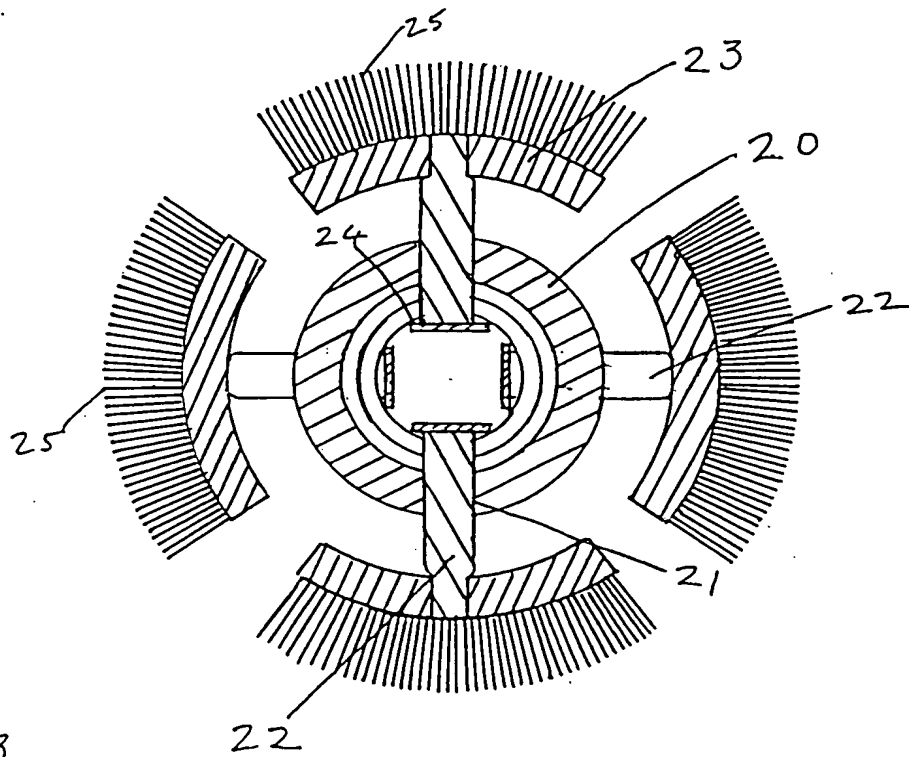


FIG. 3.

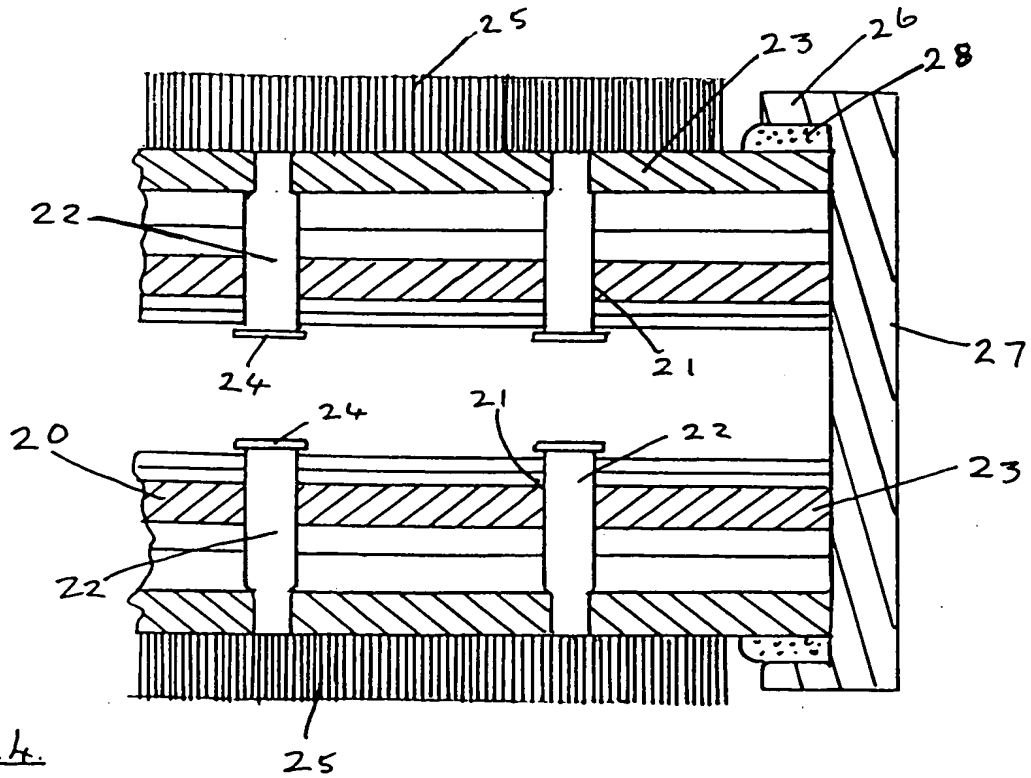


FIG. 4.

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18th Jan '99

URQUHART DYKES & LORD